

# **Problem Solving**

## **Lecture 2**

# **INTRODUCTION TO PROBLEM SOLVING**

- **Engineers must analyze and solve a wide range of technical problems. Some will be reasonably simple single-solution problems. Others will be open-ended and will likely require a team of engineers from several disciplines. Some problems may have no clear solution.**

# **INTRODUCTION TO PROBLEM SOLVING**

- **PROBLEM SOLVING INVOLVES:**
  - **EXPERIENCE**
  - **KNOWLEDGE**
  - **PROCESS**
  - **ART**

**FOCUS: Computer Assisted Problem Solving**

- **Computers are good tools for solving rule-based problems using decision rules**

## **SCIENCE AND ART**

**SOME SAY ENGINEERING PROBLEM SOLVING  
REQUIRES A COMBINATION OF SCIENCE AND  
ART:**

### **SCIENCE**

- Math
- Physics
- Chemistry
- Mechanics
- Etc.

### **ART**

- Judgement
- Experience
- Common-Sense
- Know-How
- Etc.

## THE ENGINEERING METHOD

- **RECOGNIZE AND UNDERSTAND THE PROBLEM**
- **GATHER DATA (AND VERIFY ITS ACCURACY)**
- **SELECT GUIDING THEORIES AND PRINCIPLES**
- **MAKE ASSUMPTIONS WHEN NECESSARY**
- **SOLVE THE PROBLEM**
- **VERIFY THE RESULTS**
- **PRESENT THE SOLUTION**

## **ENGINEERING PROBLEM TYPES**

- **Create a new product**
  - **Invention/conceptualization**
  - **New/modified design of existing product**
- **Cost reduction**
  - **Do it faster, cheaper, better**
  - **example: Personal computers**

## **ENGINEERING PROBLEM TYPES**

- **Develop or change a procedure**
  - **Example: Warehouse inventory -- Instead of having 3 month's inventory go to "just in time"**
- **Human factors**
  - **Make our lives longer, better, easier**
  - **Examples: cruise control, moving sidewalks, management tools**
- **Add new features**
  - **Maintain current design and add new features**

## TYPES OF INFORMATION FOR PROBLEM SOLVING

- **GIVENS:** The initial condition of the problem
- **OPERATIONS:** The various actions we are allowed to perform
- **GOALS:** The desired final condition of the problem
- **PROBLEM STATE:** The state of the problem at any specific point in time
- **SOLUTION:** Completely specified the GIVENS, OPERATIONS, GOALS, and succession of PROBLEM STATES to get to GOAL state



## **STEPS IN PROBLEM SOLVING**

- **IDENTIFY THE PROBLEM**
  - **YOU CAN'T FIX IT IF YOU DON'T KNOW WHAT IS BROKEN.**
- **DETERMINE WHAT IS REQUIRED FOR THE SOLUTION**
  - **WHAT IS KNOWN?**
  - **WHAT IS UNKNOWN?**
  - **ANY RESTRICTIONS OR LIMITATIONS?**
  - **ANY SPECIAL CASES?**

## **STEPS IN PROBLEM SOLVING (CONT'D)**

- **DEVELOP A STEP-BY-STEP PLAN (ALGORITHM).**
  - **HOW ARE YOU GOING TO FIX IT?**
- **OUTLINE THE SOLUTION IN A LOGIC DIAGRAM**
- **EXECUTE THE PLAN.**
  - **KEEP TRACK OF WHAT WORKS AND WHAT DOESN'T.**

## **STEPS IN PROBLEM SOLVING (CONT'D)**

- **ANALYZE THE SOLUTION**
  - **REVISE THE PLAN AND RE-EXECUTE AS NEEDED.**
  - **KEEP THE GOOD PARTS OF THE PLAN AND ALTER THE NOT-SO-GOOD ONES.**
- **REPORT / DOCUMENT THE RESULTS**
  - **LET YOUR BOSS KNOW HOW YOUR IDEA WORKED ( in a written report ).**

# **FAILURE IS THE MOTHER OF INVENTION: THE STORY OF THE BEVERAGE CAN**

- **PROBLEM: Keep food from spoiling**
- **SOLUTION: In 1809 Nicholas Appert invented a process for preserving food in glass bottles by filling them with water to kill the bacteria. He was awarded 12 000 francs by the French government.**
  - **In 1810 Appert wrote a book L'art de Conserver (very successful and profitable).**

## THE STORY OF THE BEVERAGE CAN (continued)

- **PROBLEM:** Bottles break easily.
- **SOLUTION:** Peter Durand (London) devised a sealed tin container.
- **PROBLEM:** How to open the tin. Soldiers used knives, bayonets, and even rifle fire. A tin of roast veal carried on one of William Parry's Arctic expeditions bore the instruction, "Cut round on the top near the outer edge with a chisel and hammer." The can (iron) was .2" thick and weighed a pound (empty).

# **THE STORY OF THE BEVERAGE CAN (continued)**

- **SOLUTION(S):**
  - **1. Use steel (stronger and thinner).**
  - **2. Create specialized tools for opening cans**
    - **1858 Ezra Warner (Connecticut) got a patent for a can opener that was describes as “Part bayonet, part sickle [with a] large curved blade.”**
    - **1870 William Lyman (Connecticut) patented a can opener with a wheel that revolved around a center hole punched in the can.**

## **THE STORY OF THE BEVERAGE CAN (continued)**

- **PROBLEM:** Lyman's can opener had to be adjusted for each can size and the punching of the center hole had to be exact.
- **SOLUTION:** Modern style can opener was patented in 1925. There is still room for improvement.

# THE STORY OF THE BEVERAGE CAN (continued)

- **PROBLEM:** Thin cans lacked stiffness and buckled.
- **SOLUTION(S):**
  - 1. Add a rim at top and bottom.
  - 2. Corrugate the sides.



## **THE STORY OF THE BEVERAGE CAN (continued)**

- **PROBLEM:** Beverage cans opened with can openers had jagged edges and too big an opening.
- **SOLUTION:** The “Church Key” can opener.
- **PROBLEM:** It kept getting lost or you didn’t have it with you when you needed it.
- **SOLUTION:** Cans with discardable pull tabs, called pop tops.

# THE STORY OF THE BEVERAGE CAN (continued)

- **PROBLEM: What to do with pull tabs after removal?**
  - Discard them? - Littering
  - Make chains? - Artistic
  - Drop them in the can? - Dangerous
- **SOLUTION: Pop tops that stay attached to the can.**
- **PROBLEM: Some people with long finger nails or weak, arthritic fingers cannot open them.**
- **AND SO ON, AND ON, AND ON, AND .....**

## PROBLEM SOLVING EXAMPLE

**Problem: Fill a bottle with stones**

**Instructions:**

- **Document any assumptions that may be required**
- **Write a step-by-step procedure for solving the problem**
- **Do this in pairs first then have a solution for your table**

## **PROBLEM SOLVING EXAMPLE**

### **Assumptions:**

- **Bottle is present**
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## **PROBLEM SOLVING EXAMPLE**

### **Assumptions:**

- **Bottle is present**
- **Stones are present**
- **There are enough stones to fill bottle**
- **Bottle is empty (or at least not full)**
- **Some (or all) stones fit through opening**

## **PROBLEM SOLVING EXAMPLE**

### **Algorithm:**

- 1. Set bottle upright near stones**
- 2.**
- 3.**
- 4.**
- 5.**
- 6.**
- 7.**

## PROBLEM SOLVING EXAMPLE

### Algorithm:

1. Set bottle upright near stones
2. Check to see if bottle is full. If so, then go to Step #6
3. Pick up a stone and try to put it in bottle
4. If stone too large to fit, discard stone, and go to Step #3
5. Otherwise, the stone fits, go to Step #2
6. Stop

## Daily Assignment F1A

- **Write a detailed set of instructions (algorithm) for replacing the tire and inner tube on the front wheel of a ten-speed bicycle. The bicycle has caliper brakes that must be loosened unless the tire is not inflated. It has standard (not quick release) hubs and no front fender. The axle may not be removed from the wheel because it contains bearings. The bicycle must be ready to ride when the work described in your algorithm is completed. Organize your detailed set of instructions into logical sub-tasks. Document any assumptions you make.**



## Daily Assignment F1C

- **Your boss has asked you to instruct a new employee in the use of drawing instruments. Your task is to explain how to construct a polygon using drawing instruments. You have decided to start with construction of a regular dodecagon (12 sided polygon) using only a pencil, straightedge, and compass. Write an algorithm (a step by step procedure) to accomplish this task. Assume that the new employee has had no experience with the use of drawing instruments. You must specify which instruments are to be used. It may be useful to draw simple diagrams to help the new employee understand more easily.**